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ALAMEDA POINT
SSIC NO. 5090.3

PRC

June 25, 1996

Ms. Teresa Bernhard/Ms. Camille Garibaldi
Engineers-in-Charge
Department of the Navy
Engineering Field Activity West
Naval Facilities Engineering Command
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CLEAN Contract Number N62474-88-D-5086 (CLEAN I)
Contract Task Order 0316

Subject: Sample Size For Background Data Sets at Naval Air Station (NAS) Alameda, Alameda, California

Dear Ms. Bernhard and Ms. Garibaldi:

PRC Environmental Management, Inc. (PRC) has evaluated the remedial investigation data collected at NAS Alameda to determine the number of samples needed for each of the different soil areas to adequately conduct statistical background comparisons across the base. This letter is to report the results of this analysis to help guide sampling efforts.

As described in PRC's letter to you dated June 10, 1996, more than 20 inorganic analytes commonly occur in soils; two analytes were chosen to estimate the number of background data sets needed for NAS Alameda. The two analytes chosen for that evaluation were iron and manganese, for the following reasons:

- Both iron and manganese are common soil components
- Neither chemical is related to any site activity at NAS Alameda based on site histories
- Both chemicals are present at quantities well above detection limits at all sites (that is, they have 100 percent frequencies of detection), eliminating the potential problem of differing detection limits between sampling efforts at NAS Alameda. (Multiple detection limits can be a confounding factor in the interpretation of results.)
- U.S. Environmental Protection Agency (EPA)-established analytical methodologies for these two analytes have not changed between sampling efforts at NAS Alameda

The results of that evaluation, as reported in the June 10, 1996 letter, indicated that three distinct fill areas exist and would require separate background data sets. Those areas are presented in Figure 1.

This letter is to report the number of background samples required to statistically evaluate site and background chemical concentrations in the selection of chemicals of concern (COCs). The following methodology was used. First, a null and alternate hypothesis were defined. The null hypothesis (H_o) was that the site mean and background mean are the same; the alternate hypothesis (H_a) was that the site and background means are not the same. Rejecting the null hypothesis when it is true (deciding that the site has higher chemical concentrations than background when it does not) is a Type I error. This is represented by alpha (α) and was set equal to 0.2 and 0.1 for this analysis. As described in EPA guidance (1990), the minimum recommended confidence level should be 80 percent ($\alpha = 0.20$). The Type II error (accepting the alternate hypothesis when it is false) is represented by beta (β). This was set equal to 0.05, which is higher than the minimum β described in EPA guidance (1990). Power is defined as 1-β; therefore, the power was held constant at 95 percent.

The equation presented in Table 1 was used to estimate the number of samples that would be needed to perform a Wilcoxon Rank Sum test at $\alpha = 0.10$ and 0.20 and $\beta = 0.05$. PRC assumed that this test would be used most often because data for many analytes are not normally distributed, the frequencies of detection for many inorganic analytes is 100 percent, and multiple detection limits have not been reported for inorganic analytes at most NAS Alameda sites. The value of "c" in the equation in Table 1 was set equal to 1, because all samples will be collected from background areas. The term (1-c) in the equation was removed because a value of 0 cannot appear in the denominator. Also, PRC assumed that all samples will be useable and so the term (1-r) was not used. Therefore, the equation was reduced to the following terms: Z values at α and β, P_r, and the constant 12.

The Z values corresponding to 1-α are 1.28 if $\alpha = 0.1$ and 0.84 if $\alpha = 0.2$; the Z-value for β when $\beta = 0.05$ is 1.96. Only α was varied to determine the number of samples needed. The value for β was held constant to ensure that the probability of making a Type II error (declaring a site clean when chemical concentrations exceed background levels) remained at 0.05. The value of P_r was set equal to 0.65, corresponding to a relative shift in the standard deviations of 0.5 (also presented in Table 1). Using these Z values, the number of samples needed was calculated to be 39 when $\alpha = 0.10$ and 29 when $\alpha = 0.20$. These calculations indicate that a sample size between 29 and 39 would provide sufficient power and confidence to support a statistical comparison of site and background chemical concentrations.

Calculations were based on inorganic analytes with a relatively high frequency of detection, and the assumption that all data collected would be useable. These assumptions are likely to be met for most inorganic analytes; even if the frequencies of detection are less than 100 percent, multiple detection limits are not common for the inorganic analytes. However, power may not be as high for the organic ambient chemicals, namely polycyclic aromatic hydrocarbons (PAHs). These chemicals have lower frequencies of detection and, at NAS Alameda, multiple detection limits have been observed. In this case, the Quantile test or the Peto-Prentice test would need to be used for statistical comparison of site and ambient concentrations. The sample size needed to perform a Quantile test was estimated from Table A.5 (attached) of Appendix A in Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 3: Reference-Based Standards for Soils and Solid Media (EPA 1992). At $\alpha = 0.10$, and number of samples (n) equal to 30, the power of the test is 0.42 (using a relative shift in standard deviation of 0.5 and epsilon [ϵ, the proportion of the site that has was estimated from Table A.5 (attached) of Appendix A in Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 3: Reference-Based Standards for Soils and Solid Media (EPA 1992). At $\alpha = 0.10$, and number of samples (n) equal to 30, the power of the test is 0.42 (using a relative shift in standard deviation of 0.5 and epsilon [ϵ, the proportion of the site that has not been remediated] equal to 1). Using n = 40 and the above assumptions, the power of the test increases only slightly, to 0.46. These values are approximate because the equation assumes that the same number of samples will be collected in the reference area (n) as the site area (m), that is, m = n. This is not the case for most sites; at most sites, more than 30 or 40 samples have been collected. Therefore, the power of the test is actually somewhat higher than that reported in Table A.5, but would not approach the minimum power of 0.9 suggested by EPA guidance (1990). However, even if sample size were increased to 100, the power of the test would not increase to 0.9. This indicates that the results of the Quantile test, if it is used, should be interpreted with caution.

In conclusion, collecting a minimum of 30 background samples for each area should provide a sufficient data set to use for statistical background comparison. If you have any comments regarding this letter or would like to discuss these calculations, please call me at (303) 312-8843.

Sincerely,

Theresa K. Lopez
Senior Toxicologist

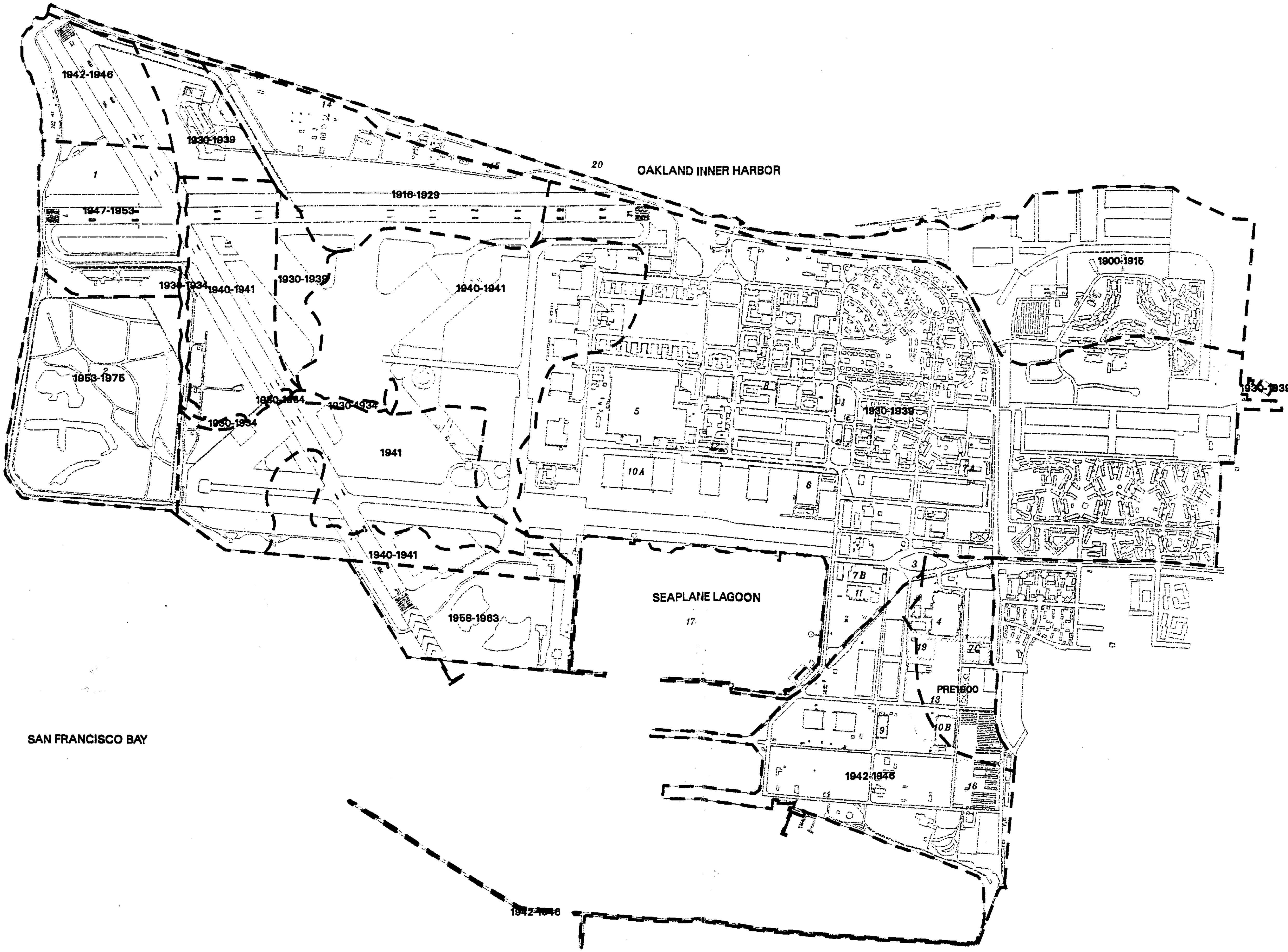
enclosure

cc: Steve Edde, NADEP
Susan Willoughby, PRC
Duane Balch, PRC

References:

U.S. Environmental Protection Agency (EPA). 1990. Guidance for Data Useability in Risk Assessment. EPA/540/G-90/008. Office of Emergency and Remedial Response. October.

EPA. 1992. Statistical Methods for Evaluating the Attainment of Cleanup Standards. Volume 3: Reference-Based Standards for Soils and Solid Media.



LEGEND

FILL AREAS

INSTALLATION RESTORATION SITES

AREA 1

AREA 2

AREA 3

600 0 600 1200

SCALE: 1" = 1200'

N

FIGURE 1
NAS ALAMEDA
DISTINCT FILL SOIL AREAS REQUIRING SEPARATE BACKGROUND DATA SETS

TABLE 1
NAS ALAMEDA
SAMPLE SIZE EQUATION

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{12c(1 - c)(P_r - 0.5)^2(1 - R)} \qquad (6.3)$$

= total number of required samples,

where

α	=	specified Type I error rate (see Chapter 2)
β	=	specified Type II error rate (see Chapter 2)
$Z_{1-\alpha}$	=	the value that cuts off $(100\alpha)\%$ of the upper tail of the standard normal distribution
$Z_{1-\beta}$	=	the value that cuts off $(100\beta)\%$ of the upper tail of the standard normal distribution
c	=	specified proportion of the total number of required samples, N, that will be collected in the reference area (see Section 6.2.1 below)
m	=	number of samples required in the reference area
P_r	=	specified probability greater than 1/2 and less than 1.0 that a measurement of a sample collected at a random location in the cleanup unit is greater than a measurement of a sample collected at a random location in the reference area.
R	=	expected rate of missing or unusable data (Chapter 3, Equation 3.1)

TABLE 1 (CONTINUED)
NAS ALAMEDA
SAMPLE SIZE EQUATION

TABLE 6.4. Values of P_r Computed Using Equation 6.10 when the Reference-Area and Cleanup-Unit Measurements are Normally Distributed with the Same Standard Deviation, σ, and the Cleanup-Unit Distribution is Shifted an Amount Δ/σ to the Right of the Reference Area Distribution

P_r	Δ/σ	P_r	Δ/σ
0.50	0.00	0.80	1.19
0.55	0.18	0.85	1.47
0.60	0.36	0.90	1.81
0.65	0.55	0.95	2.33
0.70	0.74	0.99	3.29
0.75	0.95		

From: EPA 1992

Table A.5 — Approximate Power and Number of Measurements for the Quantile and Wilcoxon Rank Sum (WRS) Tests for Type I Error Rate $\alpha = 0.10$ for when $m = n$. m and n are the Number of Required Measurements from the Reference Area and the Cleanup Unit, respectively.

Table A.5 (Continued)

						Δ/σ							
Test	m=n	r	k	α	ϵ	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Quantile	30	6	5	0.098	0.1	0.124	0.174	0.246	0.318	0.392	0.446	0.482	0.493
					0.2	0.156	0.257	0.418	0.601	0.731	0.821	0.861	0.879
					0.3	0.193	0.357	0.584	0.799	0.912	0.964	0.981	0.984
					0.4	0.221	0.457	0.718	0.906	0.976	0.995	0.999	1.000
					0.5	0.251	0.535	0.812	0.956	0.994	0.999	1.000	1.000
					0.6	0.293	0.612	0.880	0.979	0.998	1.000	1.000	1.000
					0.7	0.325	0.678	0.919	0.987	1.000	1.000	1.000	1.000
					0.8	0.360	0.735	0.943	0.994	1.000	1.000	1.000	1.000
					0.9	0.400	0.777	0.962	0.996	1.000	1.000	1.000	1.000
					1.0	0.430	0.824	0.973	0.999	1.000	1.000	1.000	1.000
WRS				0.100	0.1	0.138	0.179	0.212	0.239	0.256	0.264	0.269	0.265
					0.2	0.177	0.279	0.379	0.448	0.483	0.518	0.521	0.526
					0.3	0.241	0.412	0.563	0.665	0.726	0.755	0.762	0.776
					0.4	0.292	0.542	0.741	0.852	0.895	0.921	0.926	0.922
					0.5	0.358	0.685	0.883	0.950	0.974	0.982	0.987	0.987
					0.6	0.440	0.804	0.953	0.989	0.995	0.998	0.998	0.999
					0.7	0.505	0.893	0.987	0.998	1.000	1.000	1.000	1.000
					0.8	0.587	0.949	0.998	1.000	1.000	1.000	1.000	1.000
					0.9	0.663	0.980	1.000	1.000	1.000	1.000	1.000	1.000
					1.0	0.730	0.993	1.000	1.000	1.000	1.000	1.000	1.000
Quantile	40	6	5	0.098	0.1	0.134	0.192	0.278	0.393	0.507	0.582	0.624	0.652
					0.2	0.168	0.294	0.492	0.694	0.844	0.924	0.954	0.968
					0.3	0.198	0.403	0.662	0.879	0.966	0.993	0.997	0.999
					0.4	0.239	0.515	0.790	0.946	0.992	0.999	1.000	1.000
					0.5	0.285	0.593	0.874	0.975	0.997	1.000	1.000	1.000
					0.6	0.325	0.665	0.913	0.989	1.000	1.000	1.000	1.000
					0.7	0.360	0.730	0.943	0.995	1.000	1.000	1.000	1.000
					0.8	0.391	0.776	0.962	0.997	1.000	1.000	1.000	1.000
					0.9	0.430	0.811	0.973	0.998	1.000	1.000	1.000	1.000
					1.0	0.465	0.848	0.980	0.999	1.000	1.000	1.000	1.000
				0.100	0.1	0.139	0.189	0.228	0.264	0.281	0.296	0.301	0.303
					0.2	0.197	0.310	0.418	0.501	0.560	0.584	0.601	0.600
					0.3	0.268	0.473	0.647	0.761	0.816	0.839	0.848	0.850
					0.4	0.336	0.635	0.832	0.917	0.951	0.963	0.969	0.969
					0.5	0.423	0.768	0.939	0.983	0.993	0.996	0.996	0.997
					0.6	0.500	0.879	0.986	0.998	0.999	0.999	1.000	1.000
					0.7	0.591	0.947	0.999	1.000	1.000	1.000	1.000	1.000
					0.8	0.672	0.983	1.000	1.000	1.000	1.000	1.000	1.000
					0.9	0.743	0.995	1.000	1.000	1.000	1.000	1.000	1.000
					1.0	0.818	0.998	1.000	1.000	1.000	1.000	1.000	1.000

From: EPA 1992